

Quantum Sensors and High Energy Physics

Surjeet Rajendran, UC Berkeley

Grand Challenge of High Energy Physics

Standard Model experimentally established

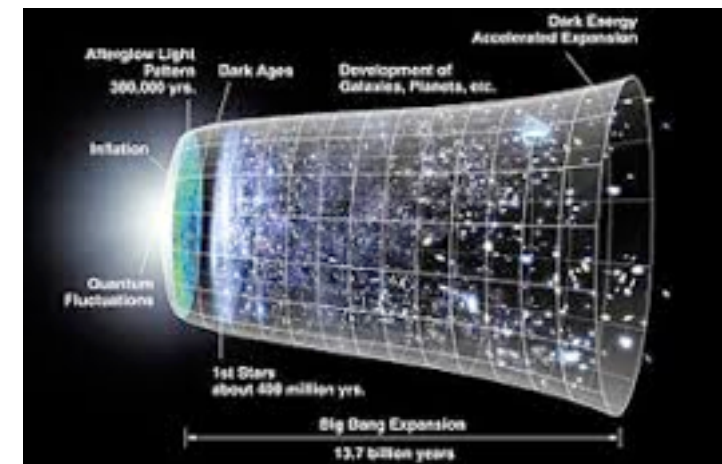


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We **know** there is new physics out there



Matter?

Dark Matter

Hierarchy

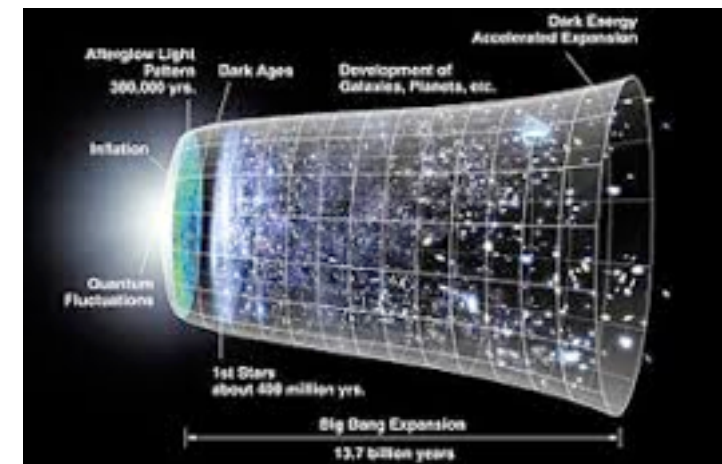
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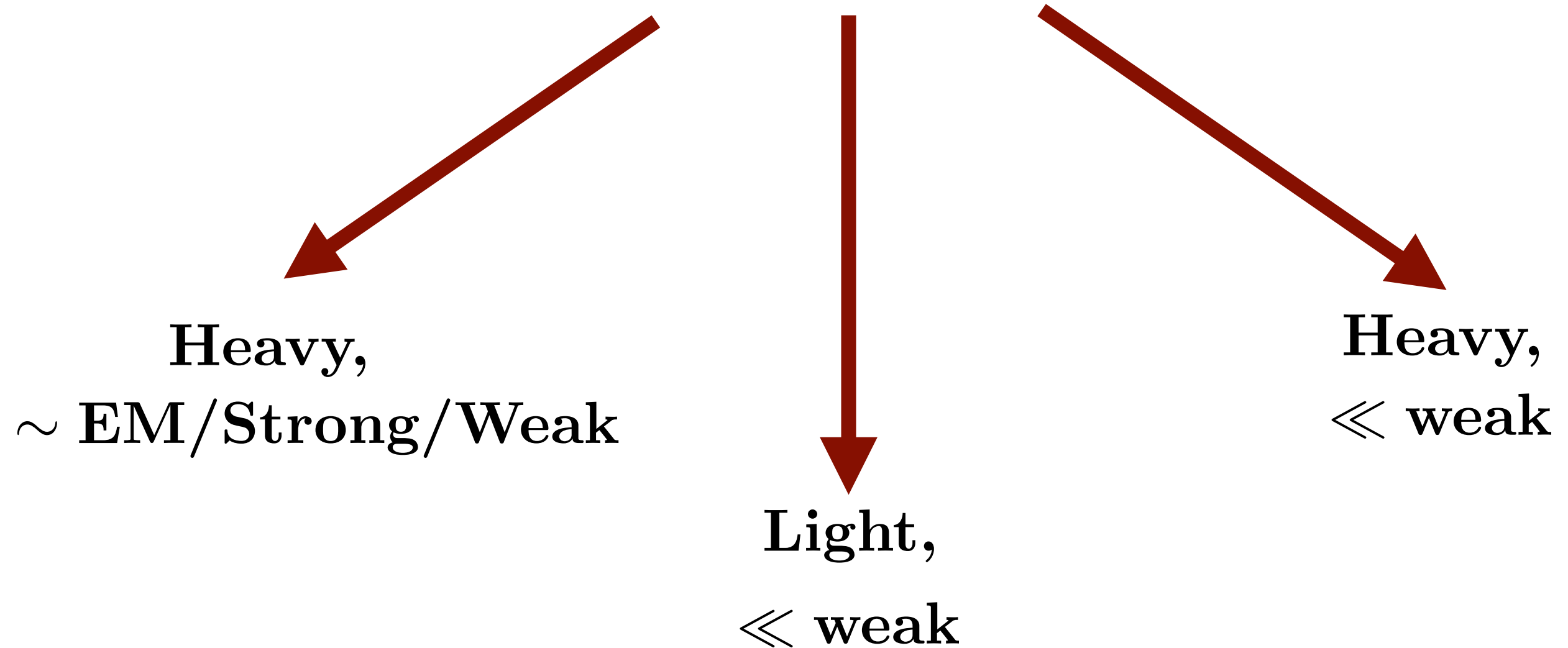
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Mass? Interactions?

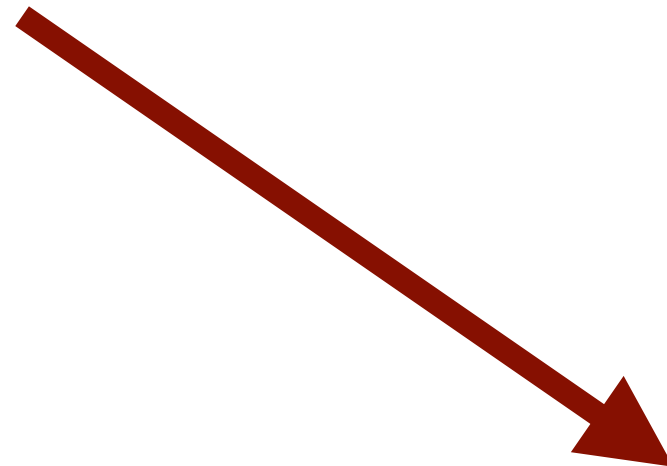
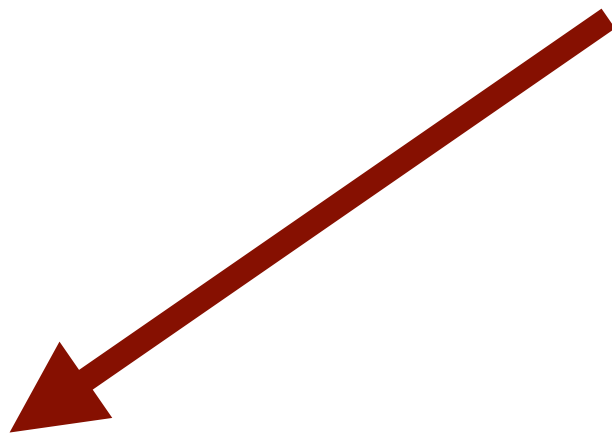
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Heavy,

\sim EM/Strong/Weak

High Energy
Accelerators

High Luminosity
Machines

Remarkable
Evolution!

Light,
<< weak

Heavy,
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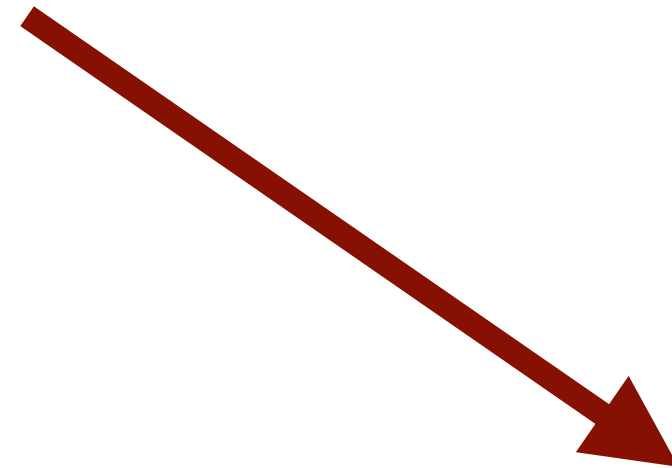
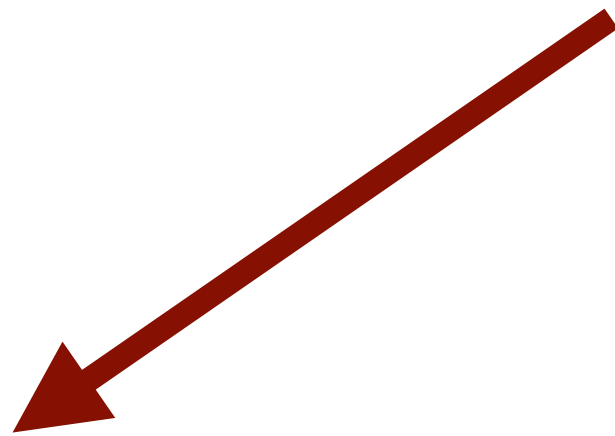
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High Luminosity
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High Intensity or
Cosmic Production

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Detection?
Quantum Sensors!



The Ultra-Light Frontier

Dark matter may be hint of ultra-light sector - axions, hidden photons
make great dark matter candidates

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Recent Theory Connection: Cosmological Relaxation of the
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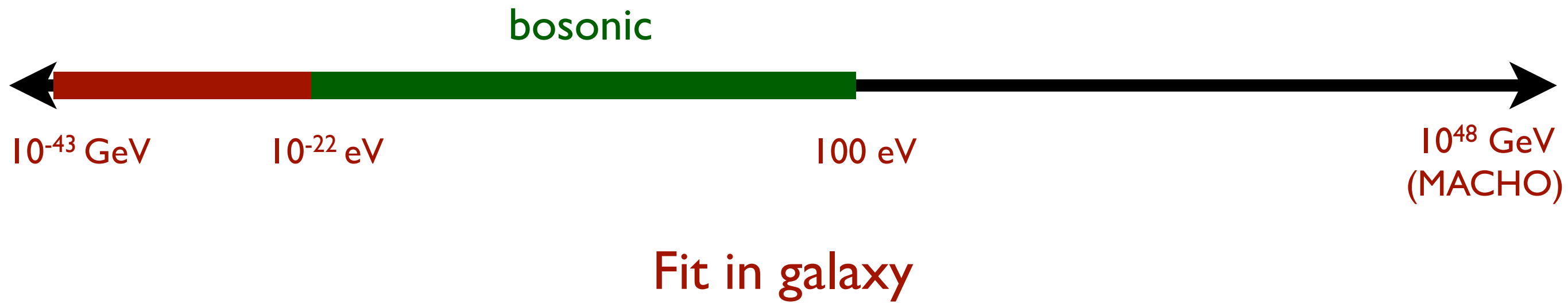


Slow processes (like erosion) can tune. Ultra-light particles!

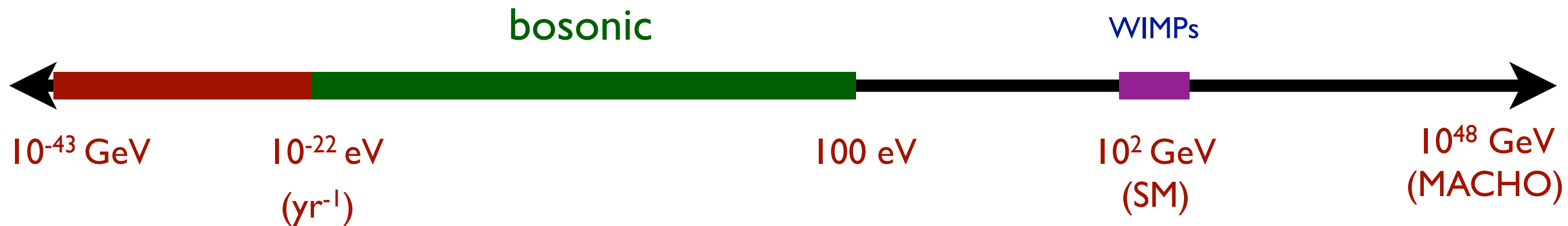
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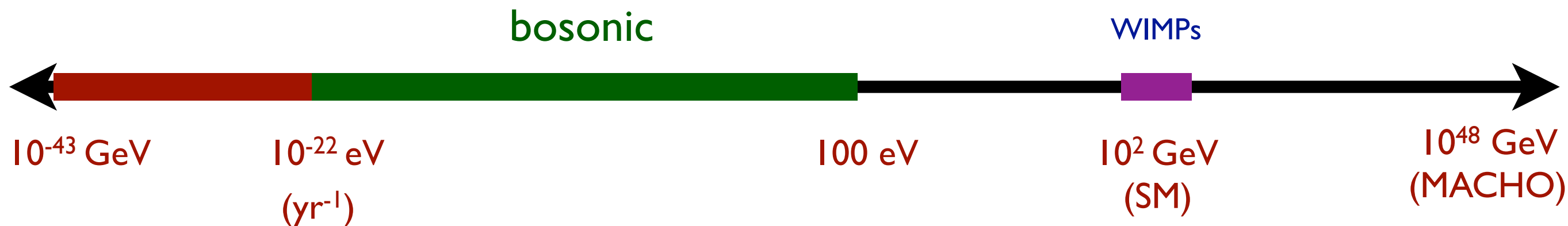


Fit in galaxy

Standard Model scale ~ 100 GeV

One Possibility: Same scale for Dark Matter?
Weakly Interacting Massive Particles (WIMPs)

The Problem of Dark Matter



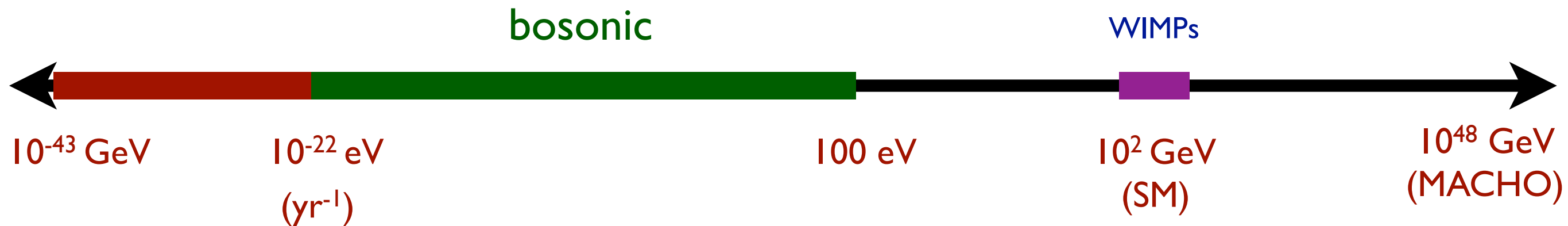
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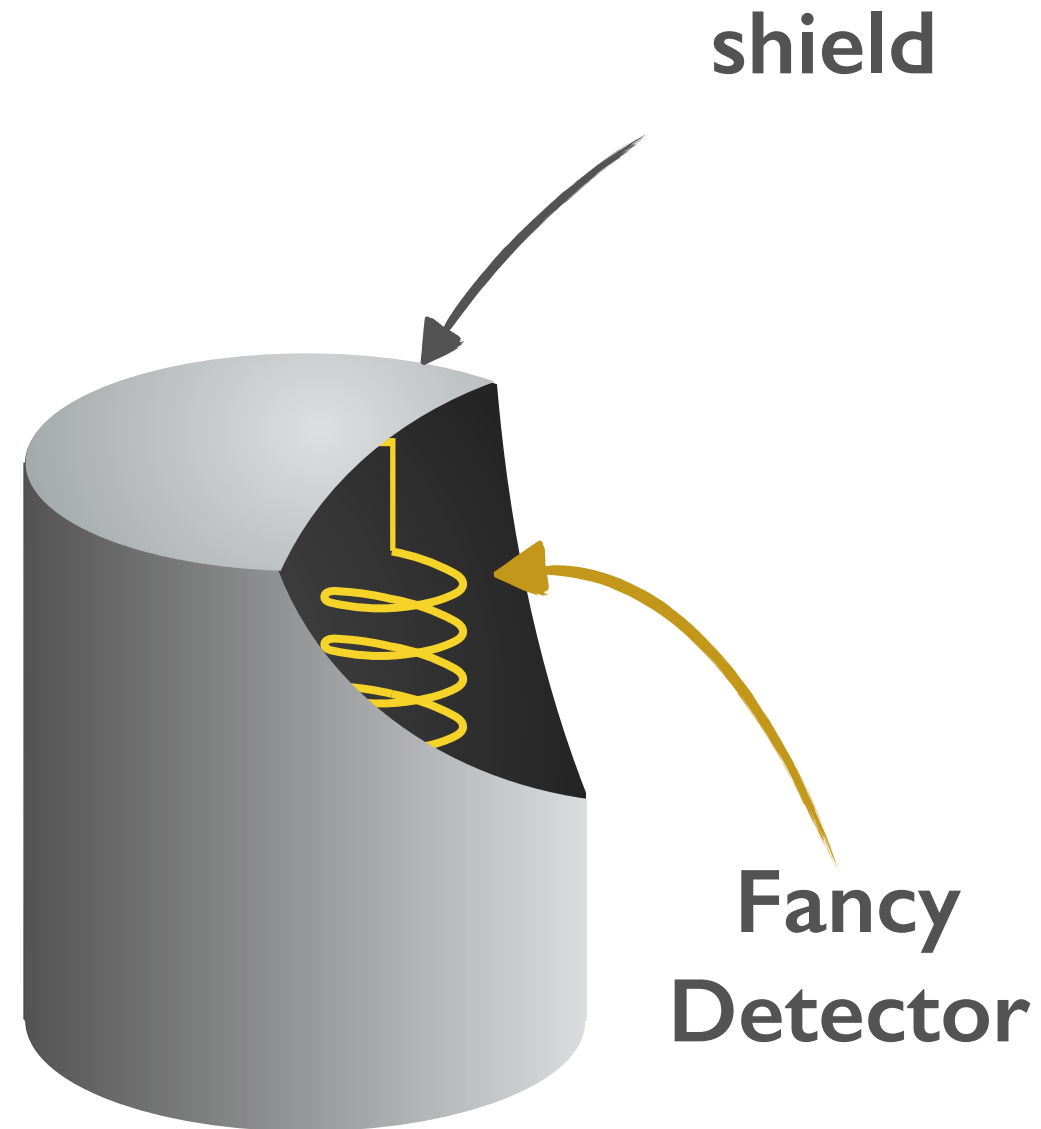
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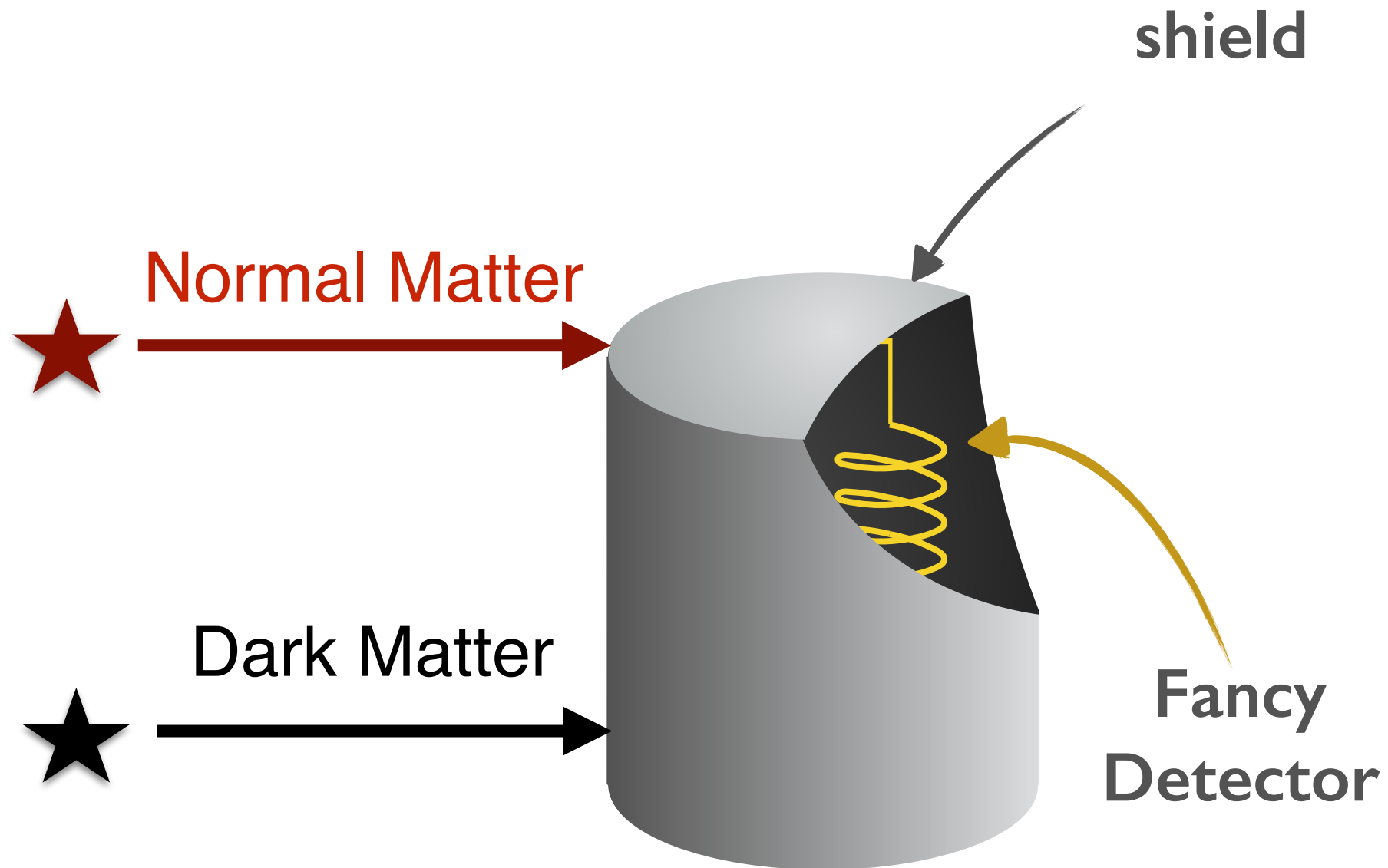
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How do we search for them?

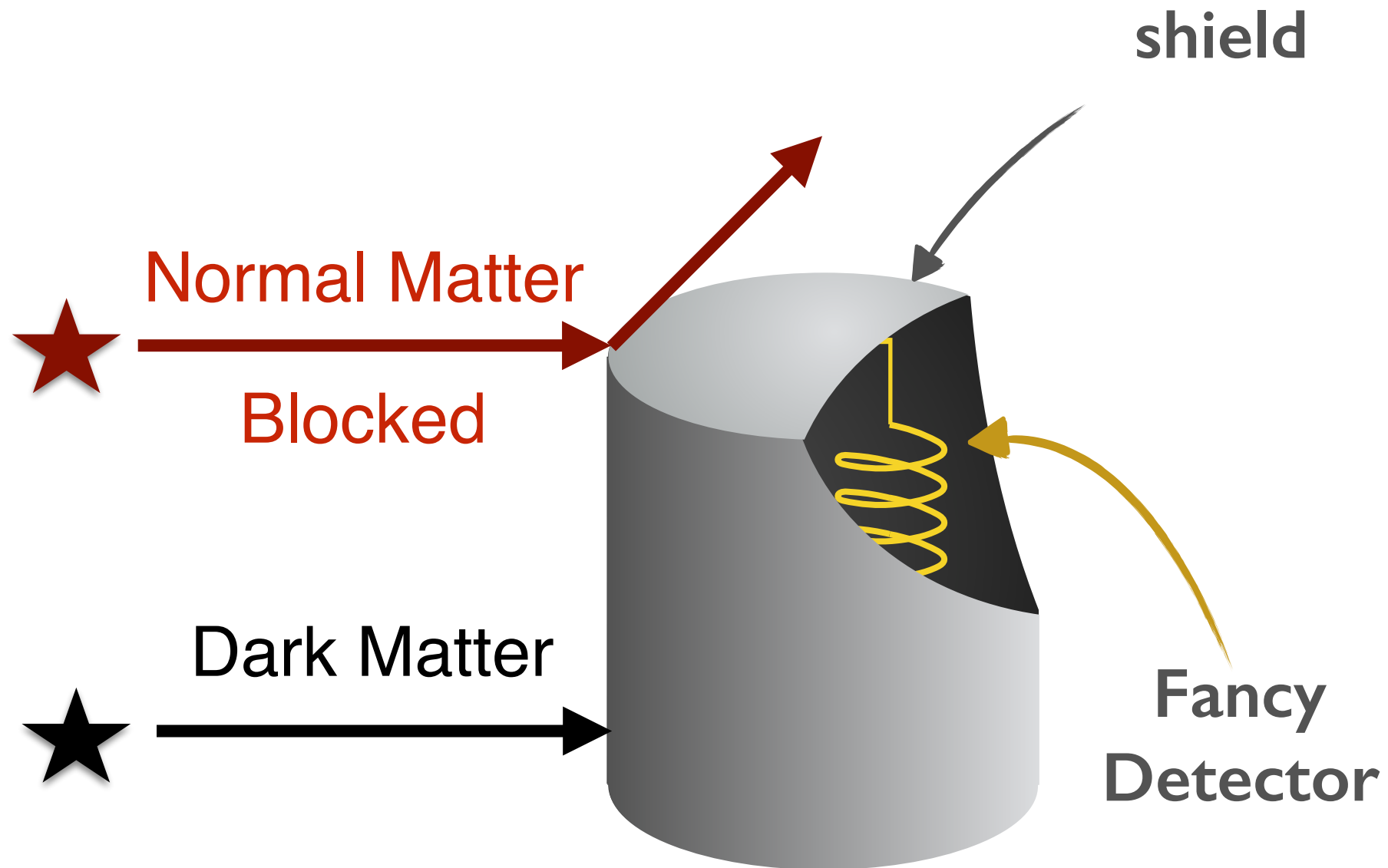
Dark Matter Detection: The Basic Plot



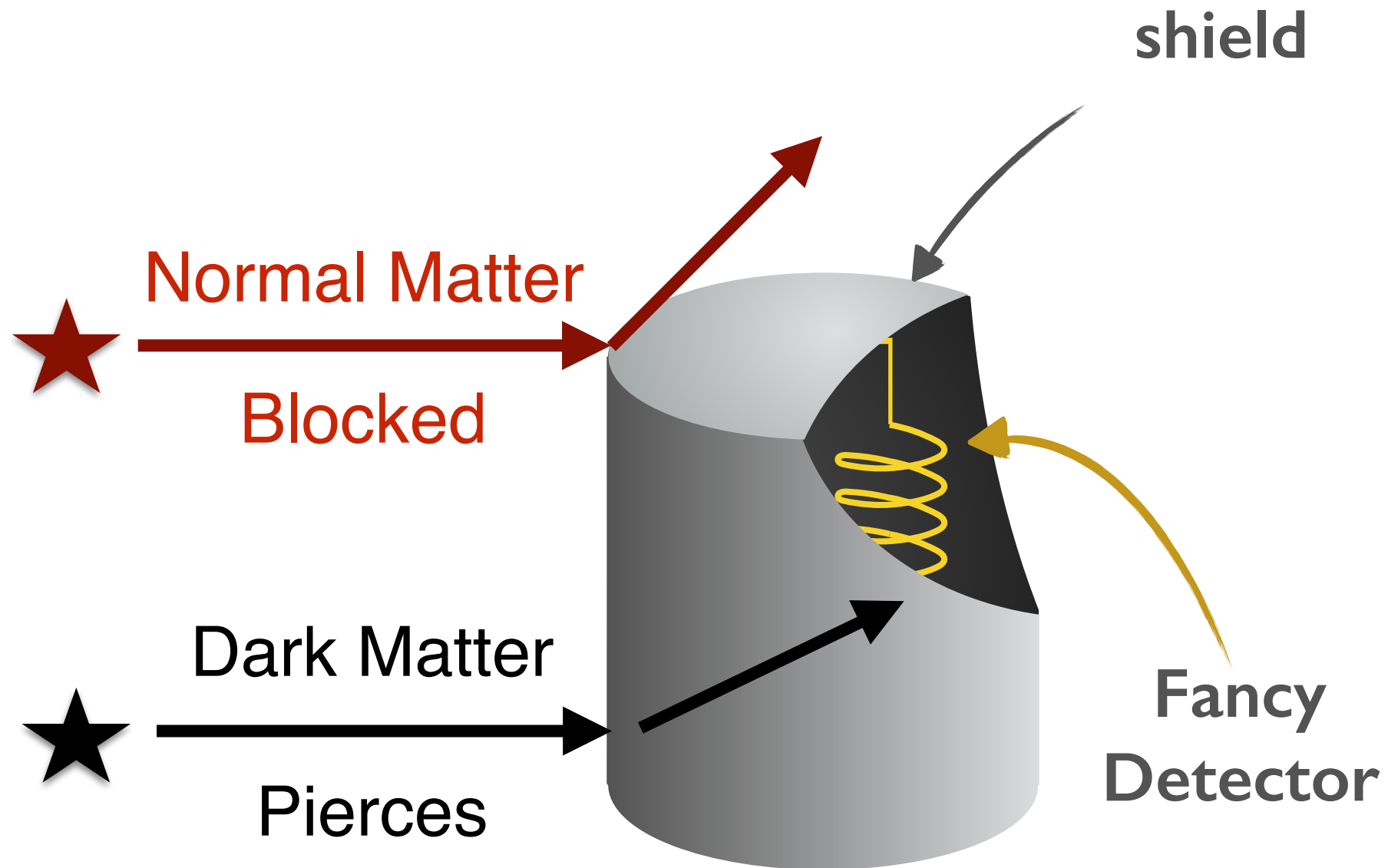
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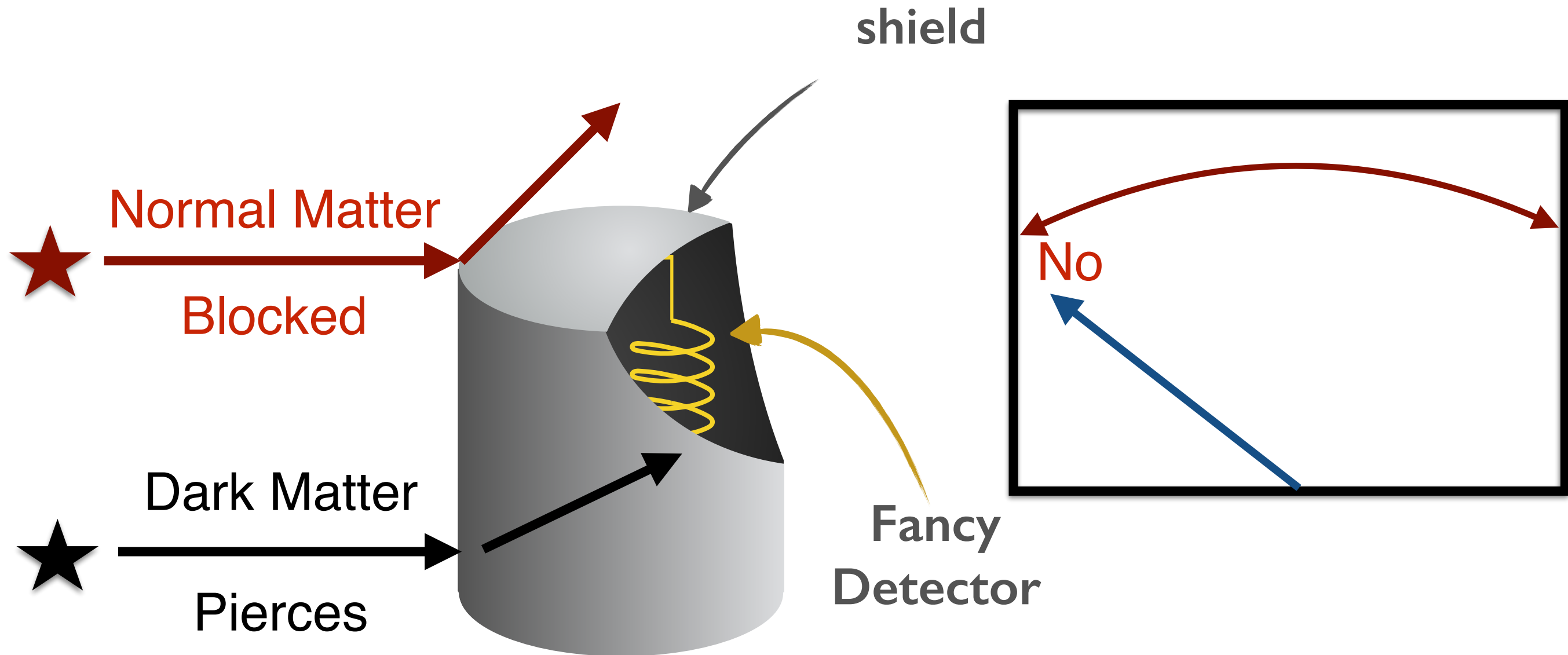
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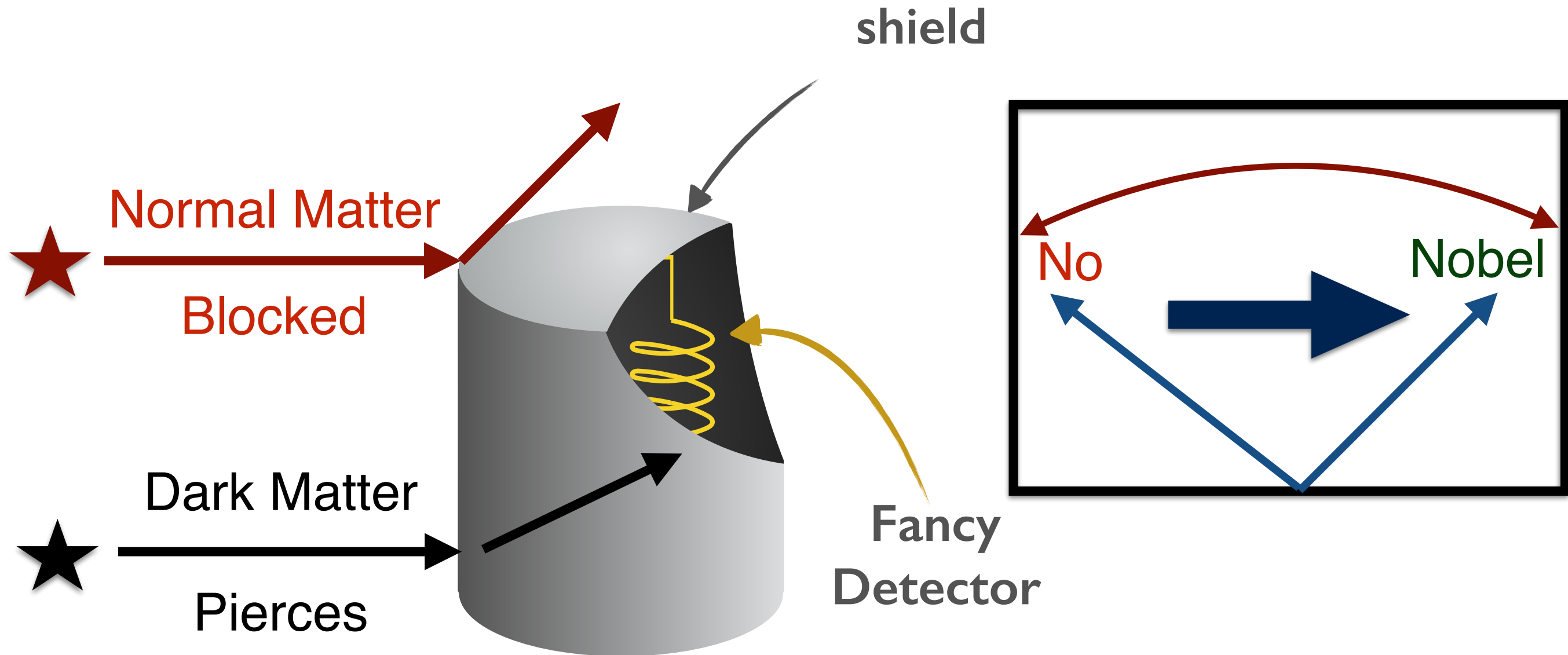
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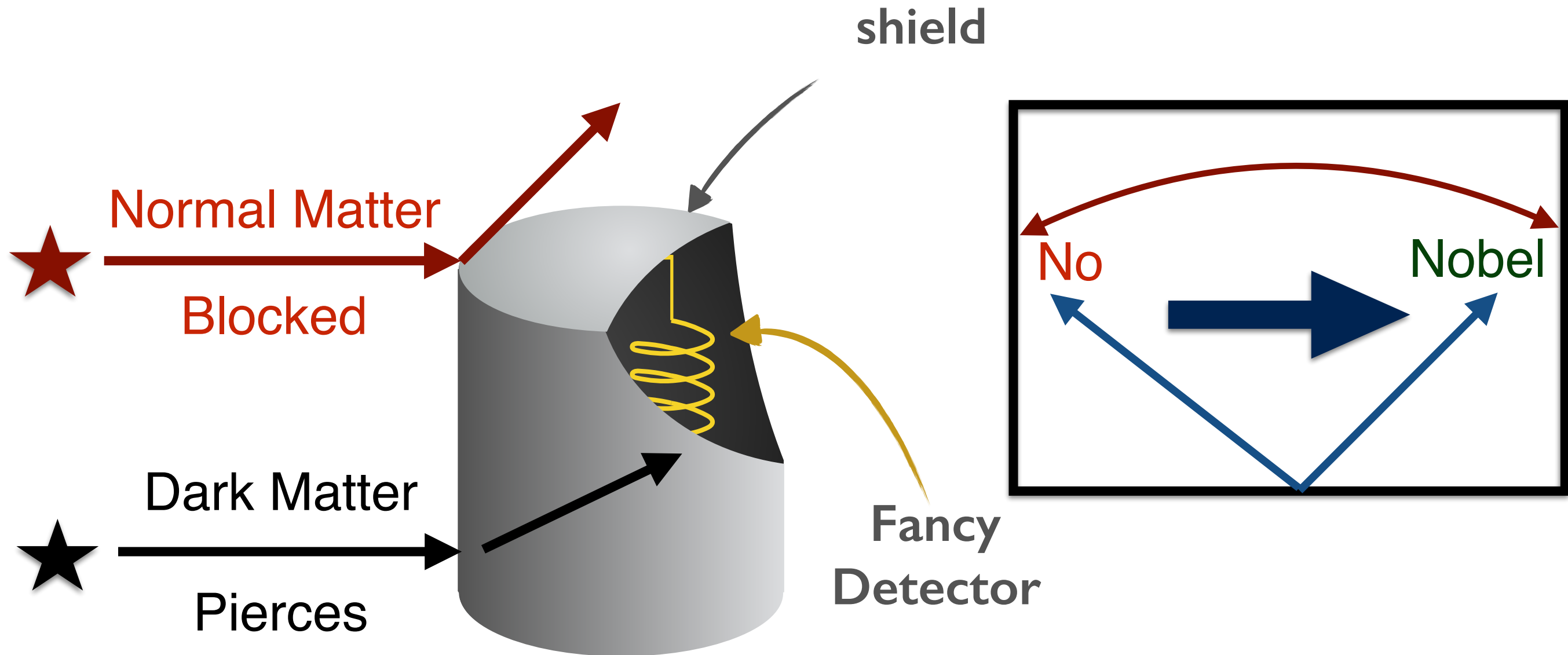
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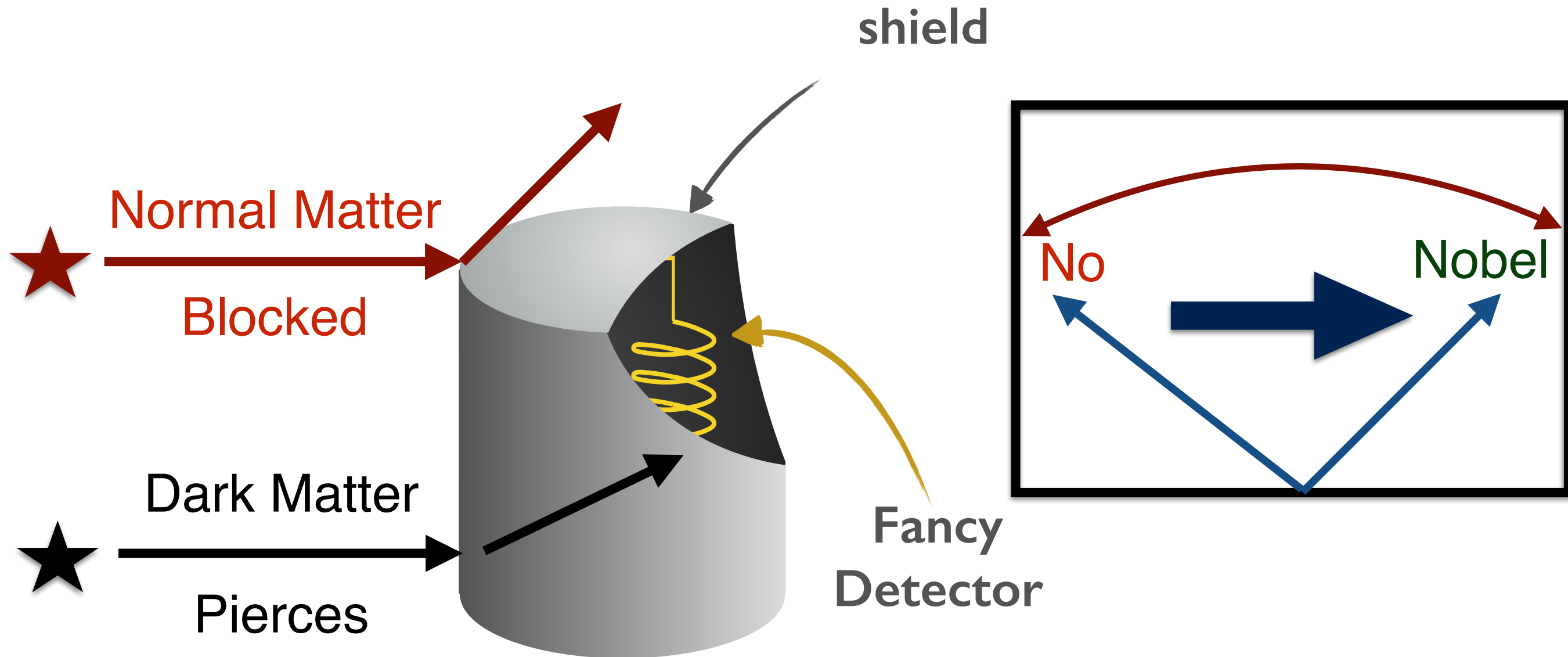


Dark Matter Detection: The Basic Plot



Fancy Detector: Quantum Sensor

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Fancy Detector: Quantum Sensor

What kinds of effects can we look for?

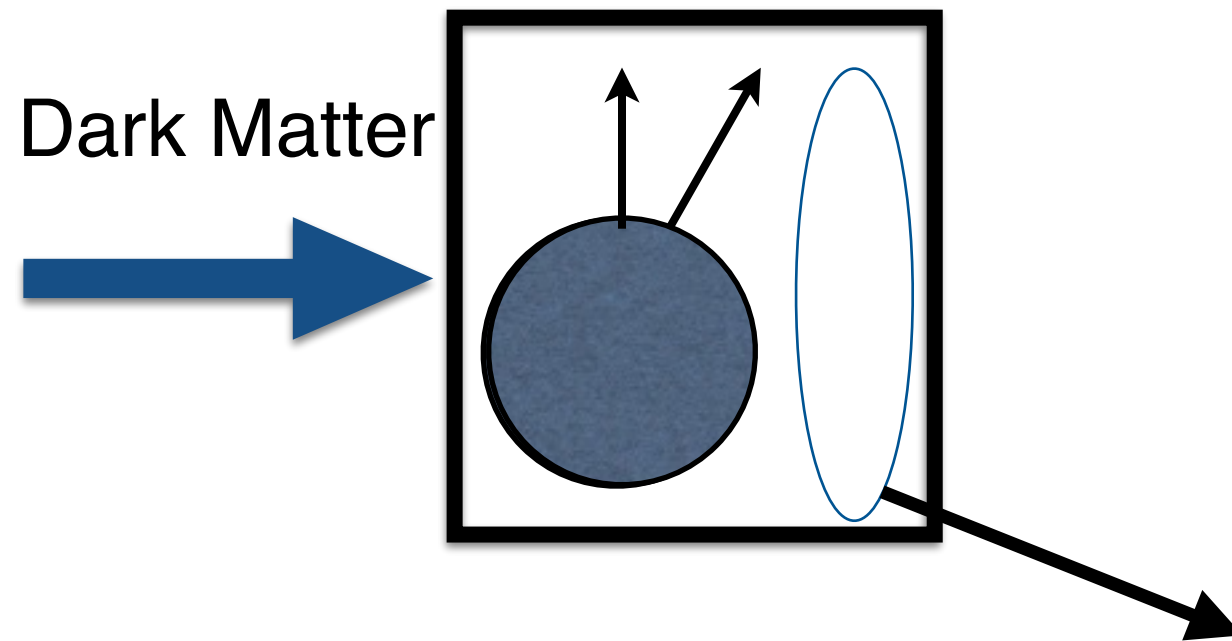
Effects of Dark Matter

Study a/c effects of dark matter on electrons, nucleons and photons

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(e.g. axion)



SQUID Sensor

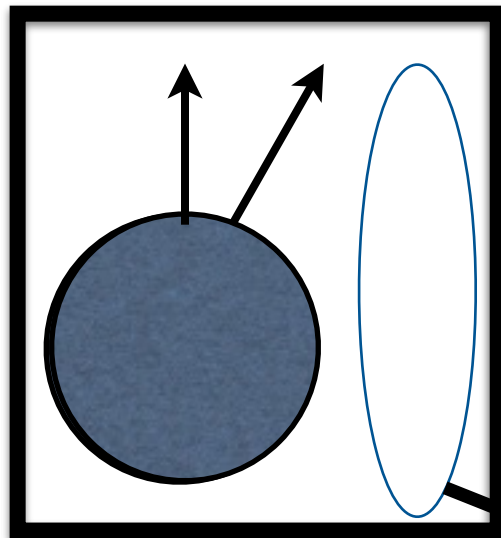
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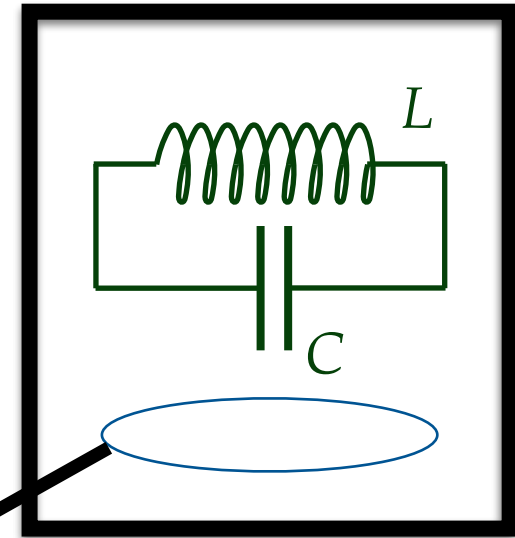
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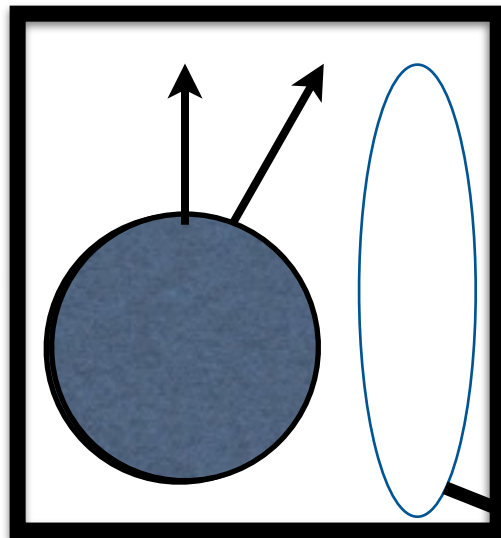
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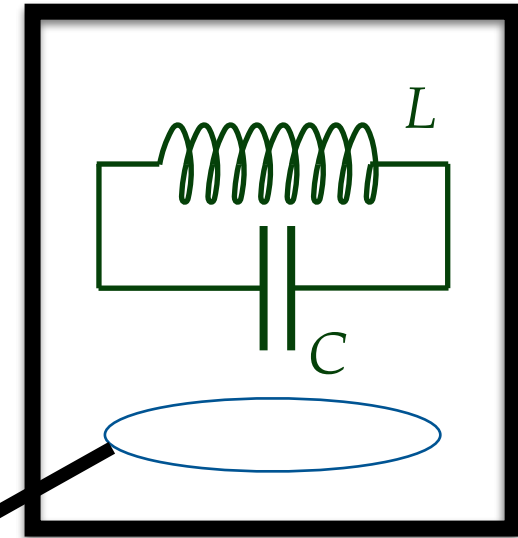
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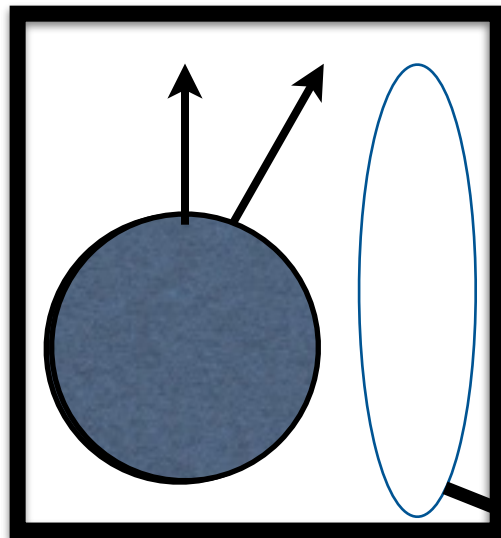
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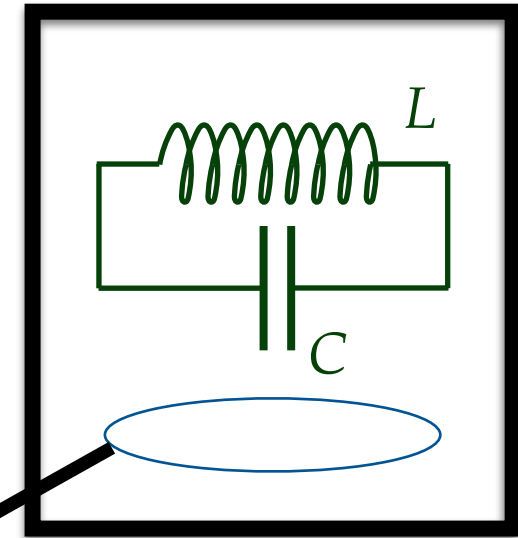
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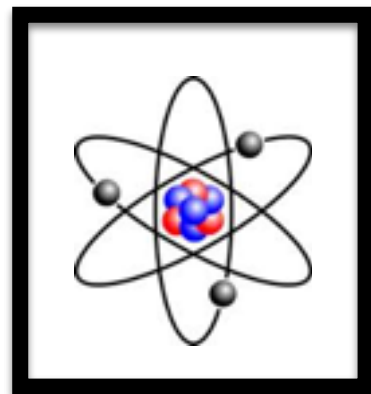
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Direct force on atoms, measure
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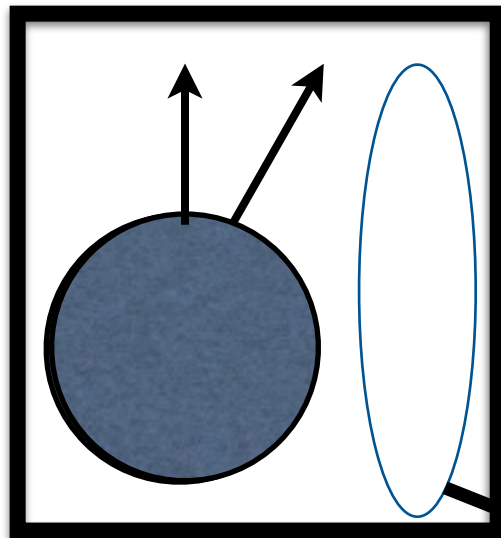
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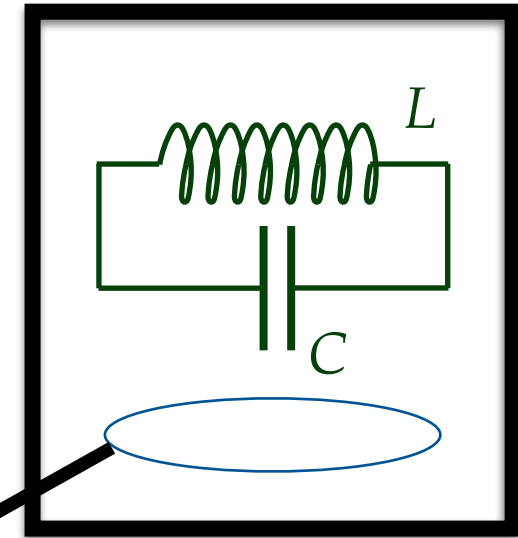
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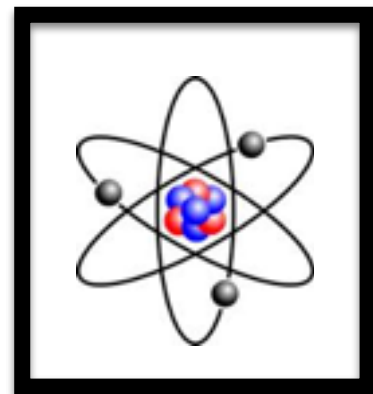
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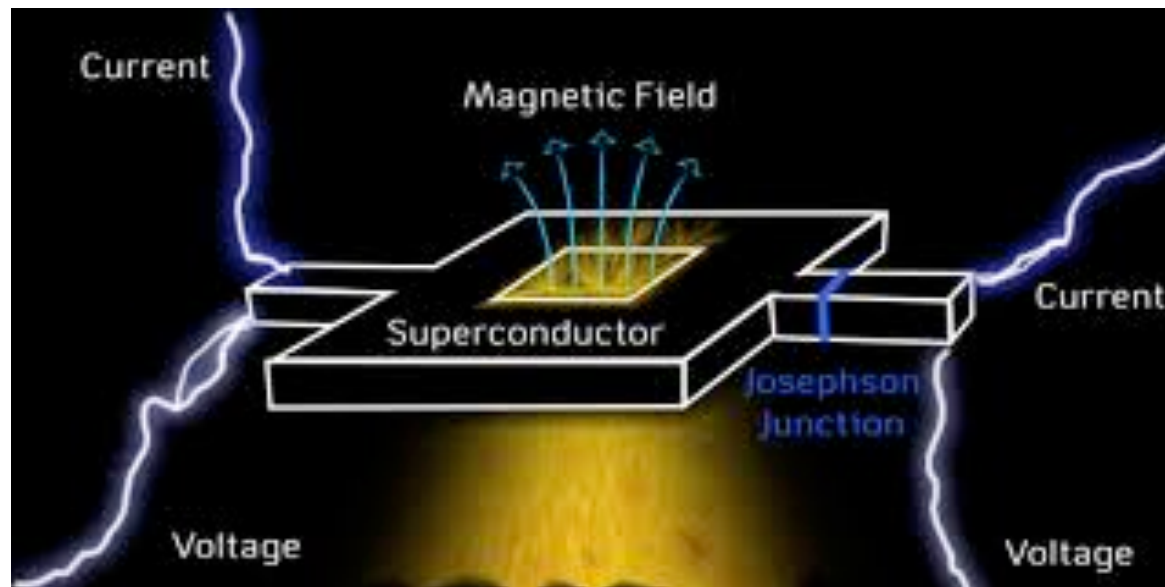
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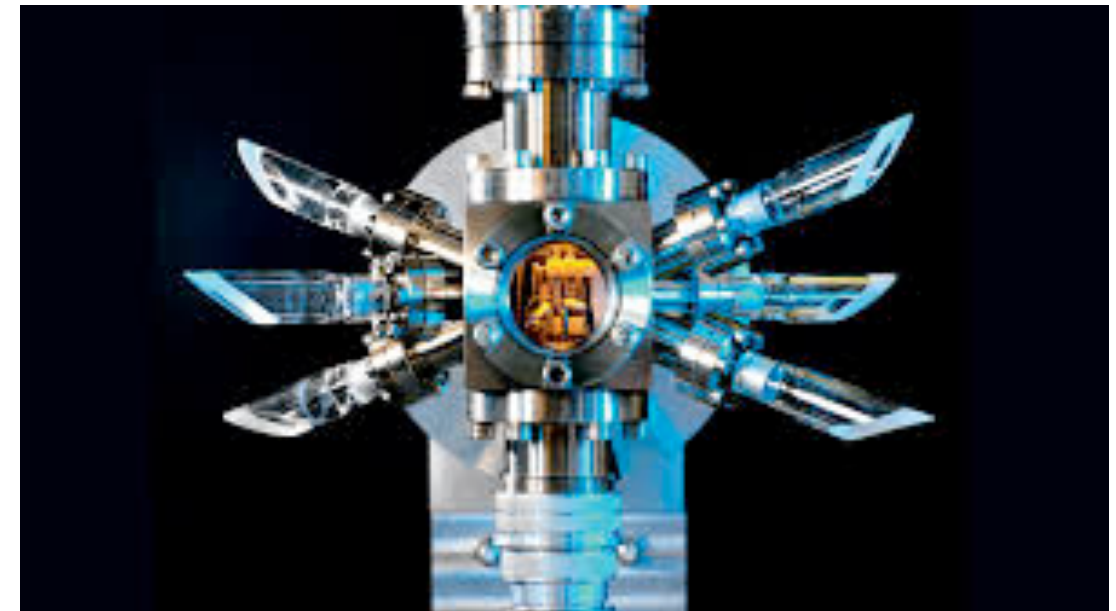
Sensitivity scales with size (volume, time...)

Precision Instruments

Impressive developments in the past two decades



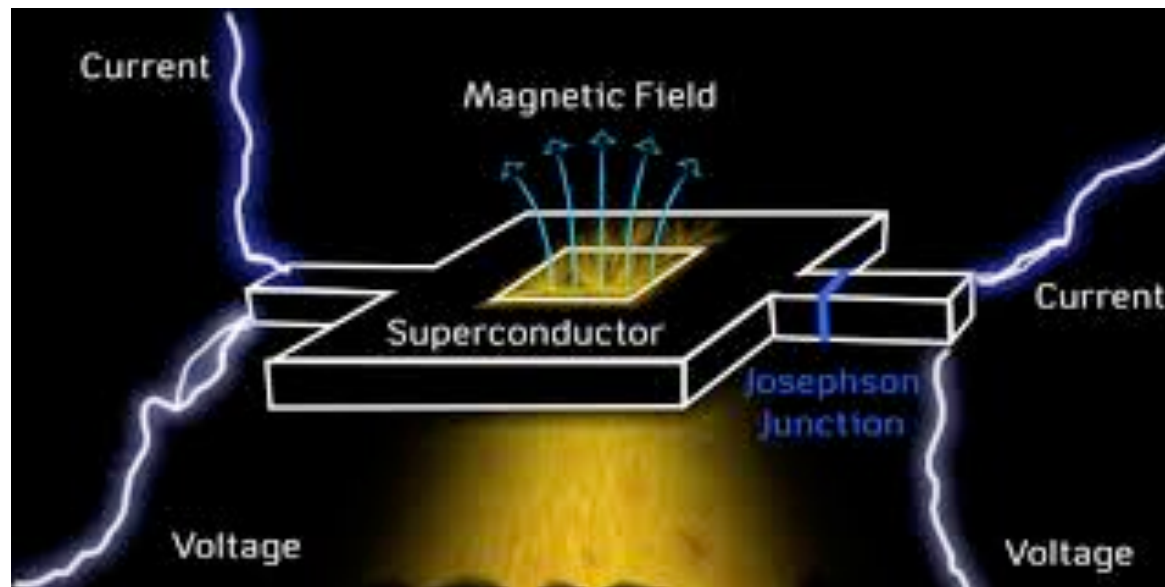
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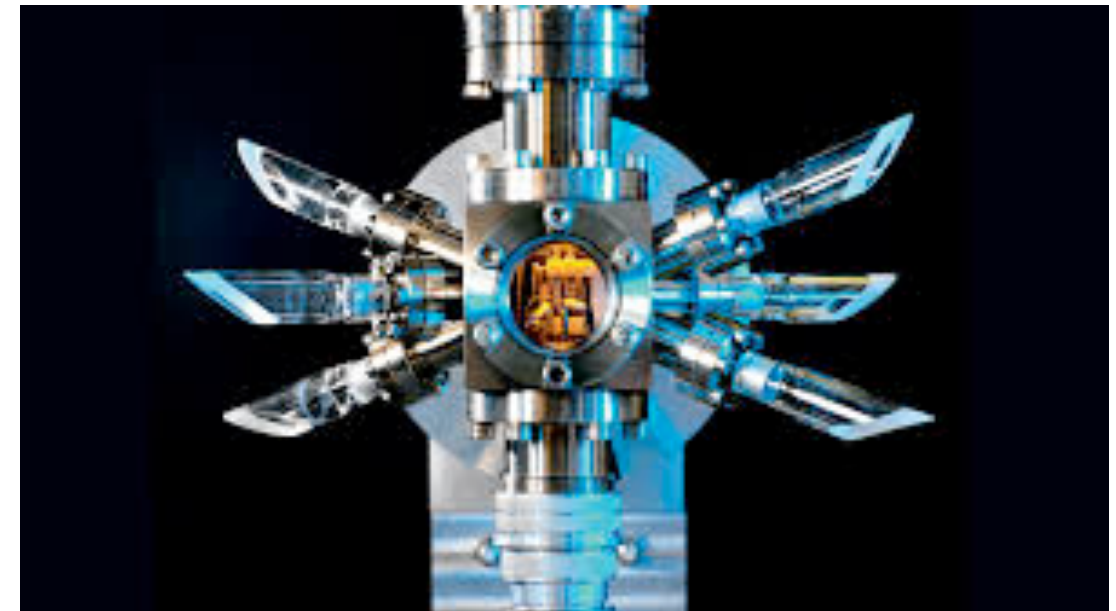
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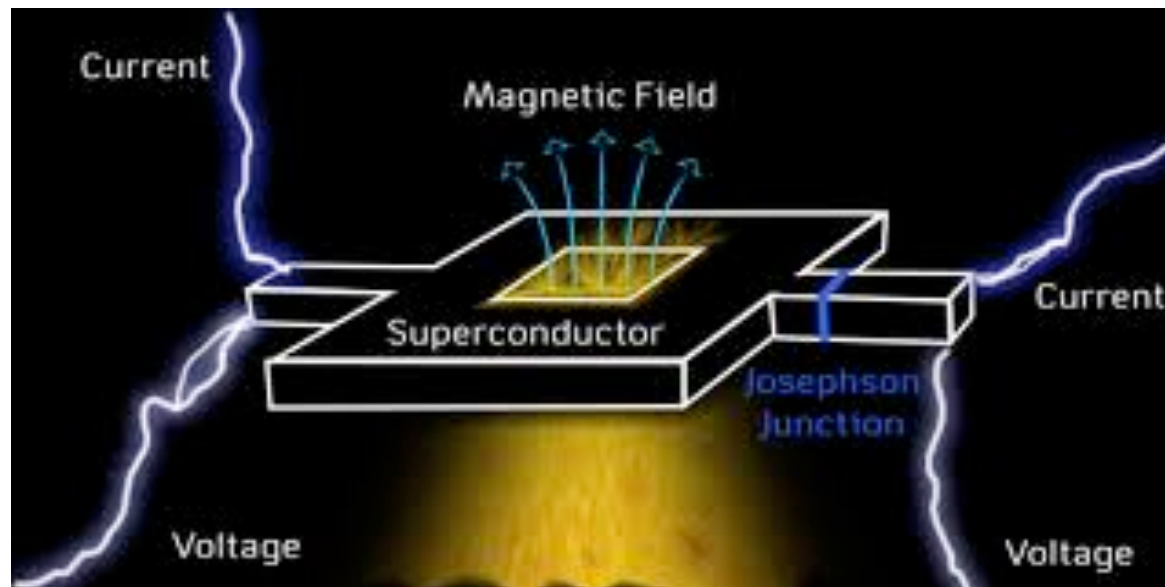
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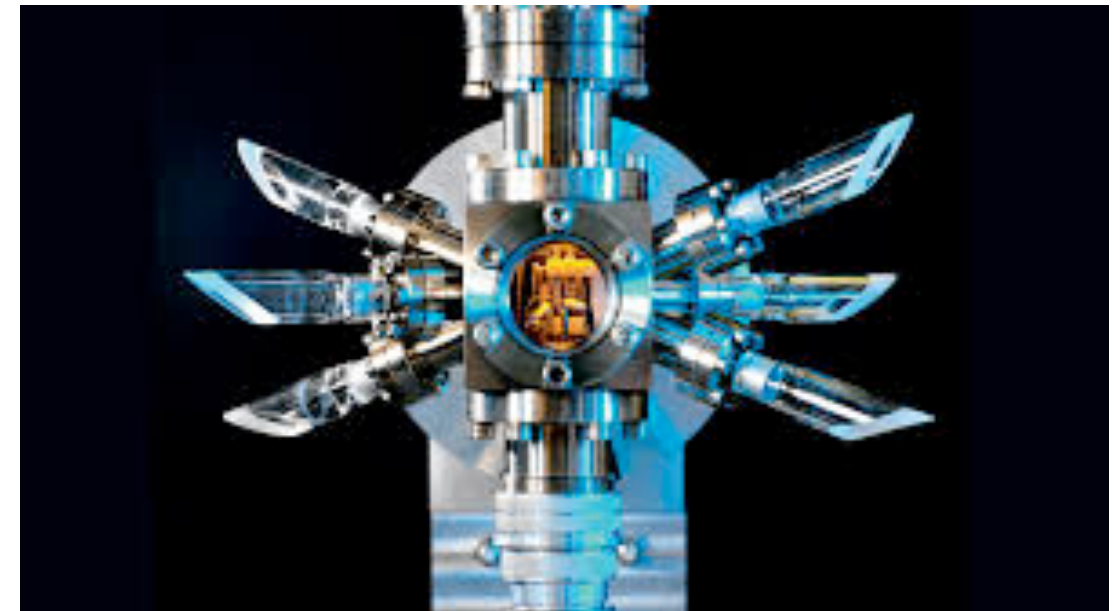
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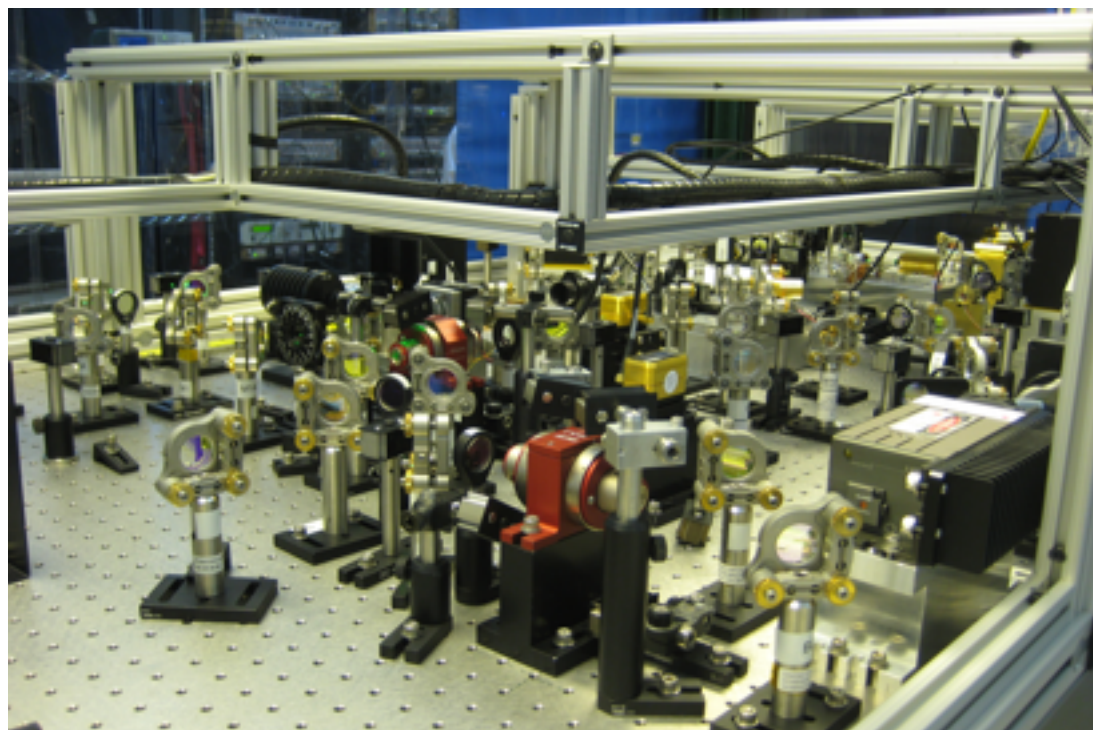
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HEP Dream: Quantum limited macroscopic sensor

QIS Dream: Quantum limited macroscopic computer

The Precision Dream



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